The Mitigation of UHI Intensity by the Improvement of Land Use Plans in the Urban Central Area: Application to Osaka City, Japan

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ABSTRACT

Osaka City is the central city of the Osaka region. The authors and other researchers have promoted some urban climate research projects with local government there. Based on results of such studies undertaken using observations and simulations, the authors are making future visions for mitigating urban heat island effects and solving some other environmental problems. Especially, the authors are proposing the "Compact Eco-City" model for Osaka City. This model includes 30% green space in Osaka City; it is less than 10% at present. The model also includes a green space arrangement that improves ventilation. The outline of this "Compact Eco-City" plan is described in this paper.

Introduction

Table 1 shows the concept of countermeasures to urban heat Island (UHI). The basic viewpoints of UHI countermeasures are as follows.
1) change of land cover/surface properties
2) reduction of anthropogenic heat
3) the utilization of the wind caused by local wind circulation; sea breeze

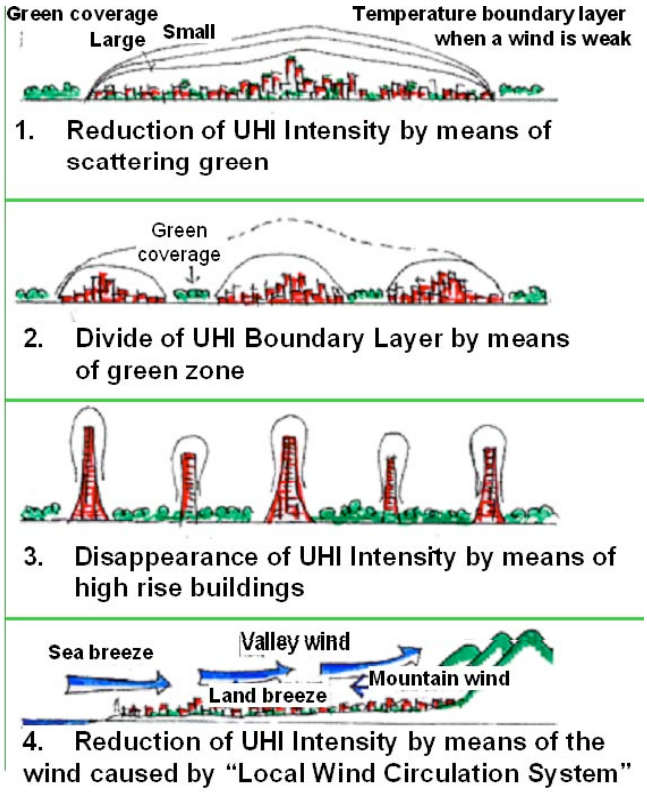
However, the consideration from the viewpoint of the horizontal space scale covered over a city is very important for the basic countermeasure of UHI. Generally, UHI intensity depends on the city size. Basically, the UHI phenomenon means the air temperature boundary layer covered over a city. As shown in Figure 1, there would be following four methods to reduce the intensity of the boundary layer over the city.
1) Reduction of UHI Intensity by means of creating green spaces, cool roofs and cool pavements.
2) Dividing of UHI boundary layer by means of green belts or water surfaces such as rivers, lakes.
3) Disappearance of UHI phenomenon by the combination of high-rise buildings and the natural earth surface at the ground level.
4) Reduction of UHI phenomenon by means of the wind caused by local wind circulation system.

On the urban scale, the countermeasure plan should have an idea coming from the urban structure. The purpose of the study is to propose the compact eco-city plan in Osaka, which is conducted integrally through the improvement of land use plan with the current important urban problems to be resolved.

Table 1. Concept of Countermeasures to Urban Heat Island (1)

measures / viewpoint based on scale	Change of Land Cover (Especially, Green)	Reduction of Anthropogenic Heat (Buildings, Cars)	Wind Flow - Good Ventilation (Urban Form)
Urban Temp. Boundary Layer Regional scale 1:25000	・Green Area, Roof Garden, Cool Roof (High Reflection), Keeping Water Pave., etc. ・Introduce Large Green Area, Green Belt for Dividing	・Energy Saving ・Transportation ・District Heating and Cooling System Using Natural Energy	・Reduction of UBL by Local Wind such as Sea Breeze, Cold Air Drainage ・Air Exchange between Upper Air and Earth Surface
Environmental Design of Outside Space District scale 1:2500	・Visual and Thermal Design for Health, Comfort ・Prevention of Thermal Storage by Road Surface …	・Heat Release Method from Buildings (latent heat) and Cars, and its Location and Place	・Ventilation and Air Exchange by Form of Town, Arrangement of Buildings, Water Front, Open Spaces, Direction of Streets..

Figure 1. Concept of Countermeasures to Urban Heat Island (2)



Present Condition and Necessity of Change in Osaka City

The population of Osaka city is 2.65 million and the city area is 222.3 km^2. The population density is very high. As shown in Figure 1 and 2, the Osaka area is among the hottest areas of Japan. Local governments are striving to mitigate urban heat island effects. For example, Osaka Prefecture Government produced the "Osaka Prefecture Heat Island Measures Promotion Plan (2004)," the "Thermal Environment Map (2006)," and the "Heat Island Measures Guideline (2007)," which is based on "Thermal Environment Map".

Figure 2. Location of Osaka City in Japan

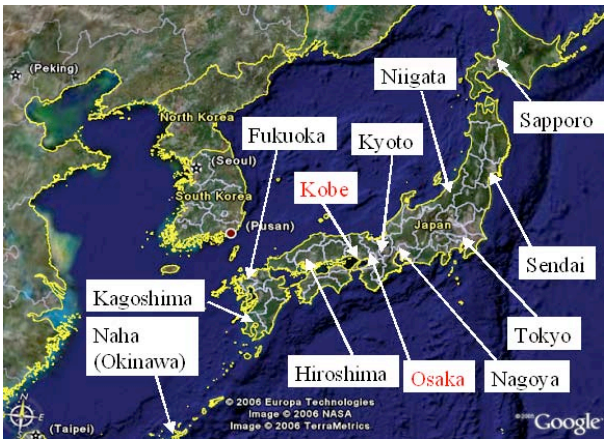
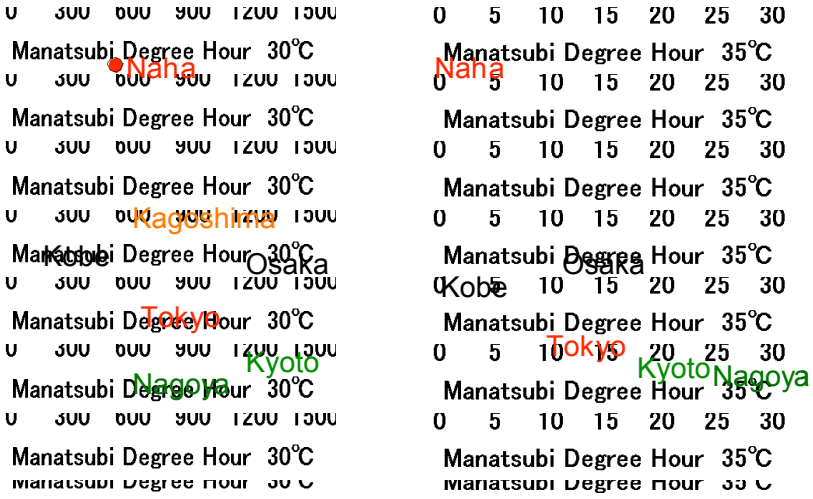


Figure 3. The Comparison of Summer Heat Severity in Japanese Large Cities
(Analysis Period : 2000～2004　5 Years Average)

"Nettaiya Degree Day" is the severity index of minimum temperature. It is the integrated value of the differences between the minimum and reference temperatures.

"Manatsubi Degree Hour" is the severity index of maximum. It is the integrated value of the differences between the hourly temperature and the reference temperature.



The Policy of New Land Use Plan

The policy of the plan is based on the current urban problems in Japanese cities to be resolved. There are 3 important points in Osaka city.
1) Reproducing/increasing green spaces and restoring water front spaces inside central city area for climate control and amenity. It is very important not only for the counter-measures of UHI, but also for the physical and mental health of people.
2) Good public transportation systems are needed. Osaka city already has good subway systems. New transportation systems such as LRT and pedestrian spaces for comfor-table life are needed.
3) Urban infrastructure system such as energy, water and waste for conserving resources and for protecting the environmental pollution. This is one of the reasons why cities have to be compact. Consequently, partly high density areas are reproduced. The common utilization of some services is recommended for decreasing environmental loads

Climate Analysis Map for planning

As described above, in the Osaka region, urban climate is an important issue for urban design and planning from the perspectives of urban heat island mitigation and air pollution reduction. Therefore, the authors made a Climate Analysis Map for planning (Fig. 2). This map represents the existing climate condition of discussed area (Tanaka & Moriyama, 2004). Based on this map, the authors are proposing a plan of Osaka central area for the future.

Figure 4. "Climate Analysis Map" of Osaka City

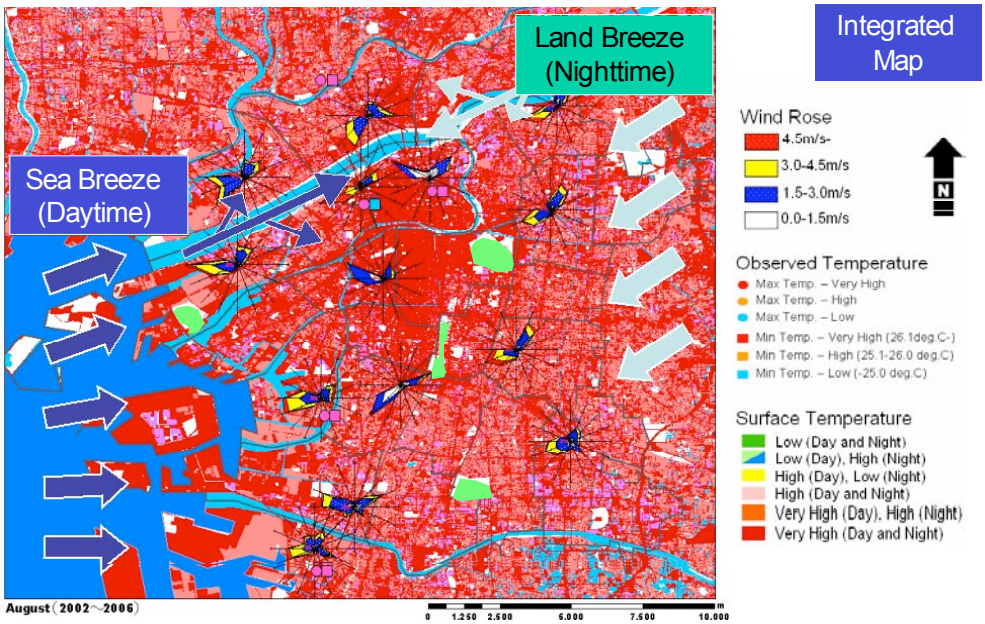


Figure 5 shows the "Kaze no Michi", ventilation lane in Osaka central area, caused by the typical sea breeze. However the roads are not in good condition to help with the air quality and the thermal environment. Figure 6 shows the example of surface temperature in Nagahori-street. The north-side lane of the street has a very high surface temperature, because the road is wide and has no street trees. There are no shade spaces.

Figure 5. Proposal of "Kaze no Michi" (Ventilation Lane) in Osaka Central Area

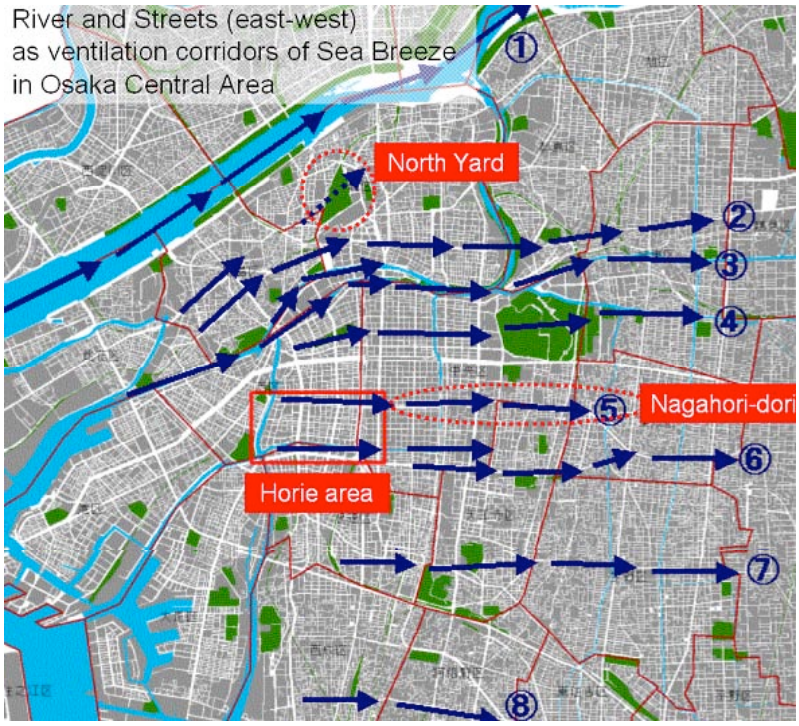


Figure 6. Surface Temperature of Nagahori-street (provided by Pasco)

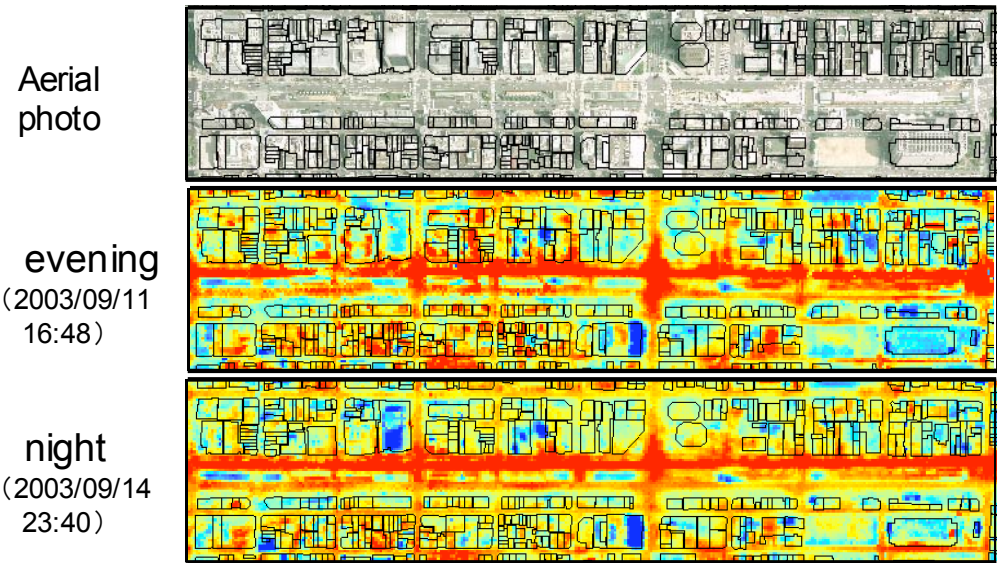
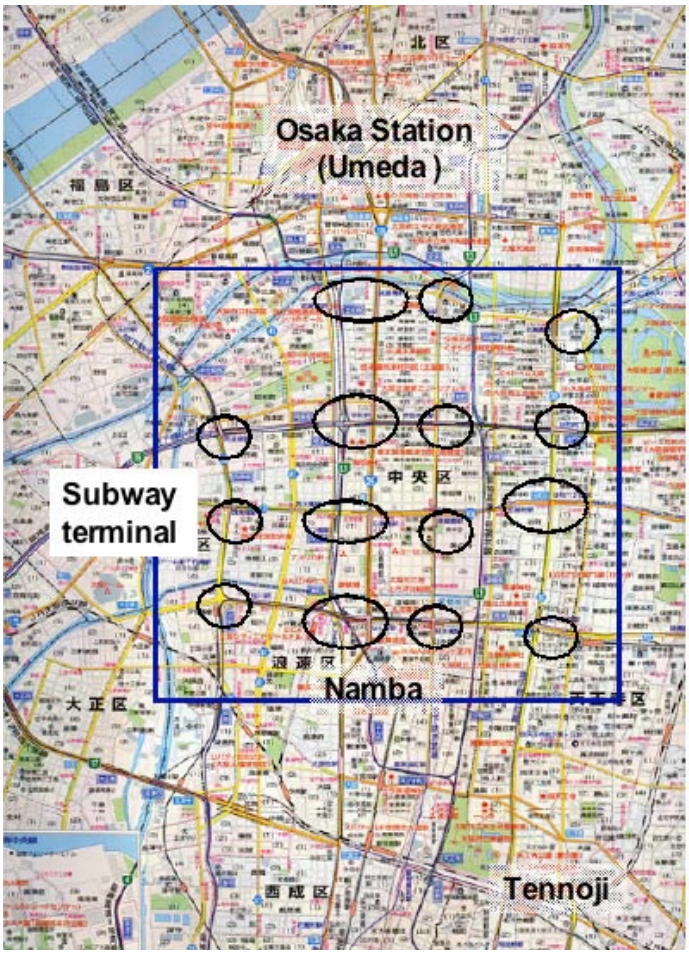


Image of New Land Use Plan for “Compact Eco-City”

The roads in Osaka central area consist of about 86m grids. The subway lines are located about every 1km intervals as shown in Figure 7. Therefore the stations for changing trains (junctions) are located regularly.

Figure 7. Policy of Osaka Grid Model



The policy of new land use plan in Osaka central area is as follows.

1) Making urban core (high-rise areas) around subway stations.
2) Dividing all focus areas into 3 types based on land use.
   (1) High-rise area for offices, commercial and public buildings.
   (2) Low-rise area for houses, residences and life.
   (3) Green areas (10%, 30%) for recreation, ecosystem conservation.
3) At first, installing green belts between terminal stations.

Green zones should be constructed from the middle blocks between stations.

Figure 8. Osaka Grid Model (Green area: 10% case)

Figure 9. Osaka Grid Model (Green area: 30% case)

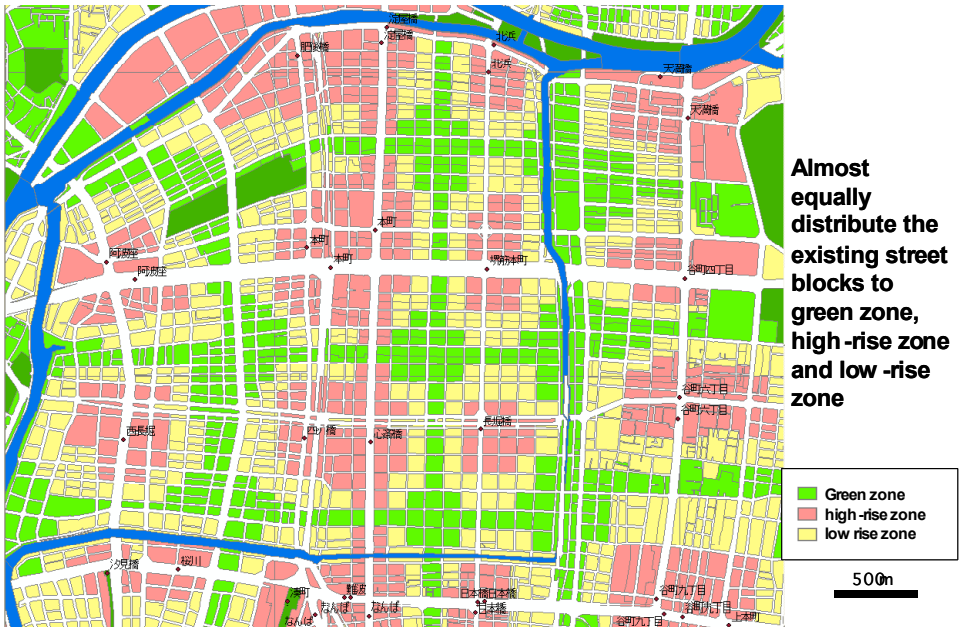


Image of Three Zones

Core zone: The core zone consists of high-rise area for offices, commercial and public buildings: It is located about 250 –300m around a subway station. For the view-point of wind flow, high-rise buildings at the central area would be more desirable than the type of courtyard that is popular in Europe.

Residential zone: The residential zone is a low-rise area for residential houses. The residential houses are located around the core zone with plentiful green.

Green zone: The middle blocks between the underground stations is green zone. The historical buildings should be conserved especially in the green zone. In some cases, they are converted to restaurants, museums, and so on.

Figure 10. Image of core zones (example of Osaka Business Park)

Conclusion

Based on the present urban problems in Japanese cities, the policy of the plan is:.
1) Increasing green spaces and restoring water front spaces inside the central city area for amenity and climate control. Preparing green spaces “30% of city area”.
2) Preparing infrastructure systems, such as water, energy and waste for conserving resources and for preventing environmental pollution, partly to concentrate mechanical services and to promote common utilization for decreasing environmental loads.
3) Preparing good public transportation systems using the existing subway system and building new transportation systems for comfortable transportation system and pedestrian spaces.

The detailed quantitative evaluations on the UHI mitigation and the other matters are needed. The countermeasures in the district scale are important with the urban scale. The method of realization is also important. One of the possible methods is the land readjustment program for creating green blocks. And the redevelopment plan should be used for the program. These points remain for future works.

Acknowledgements

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Reference

Tanaka, T., Moriyama, M., 2004: Application of GIS to make 'Urban Environmental Climate Map' for Urban Planning. Proc. 5th Conference on Urban Environment (CD-ROM).